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SILVICAL CHARACTERISTICS OF TANOAK

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CALIFORNIA
FOREST AND RANGE
EXPERIMENT STATION
KEITH ARNOLD, DIRECTOR
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Preface

The Forest Service is engaged in assembling information on the silvical characteristics of important forest trees of the United States. Much material that is of value in silviculture and research is widely scattered and difficult to locate. This report presents, in preliminary form, the information that has been collected for one species of tree. Similar reports are being prepared for other species at the California Forest and Range Experiment Station and at other forest experiment stations. Readers are encouraged to notify the authors of omissions, errors, or new information affecting the silvical characteristics of the species.

Cover picture: The spire-shaped tanoak growing on a clear-cut block in the Douglas-fir type of northwestern California is typical of tanoak trees found in dense coniferous stands. Its diameter is 32 inches at breast height and the height is 84 feet.

SILVICAL CHARACTERISTICS OF TANOAK

By D. F. Roy, Forester,
Division of Forest Management Research

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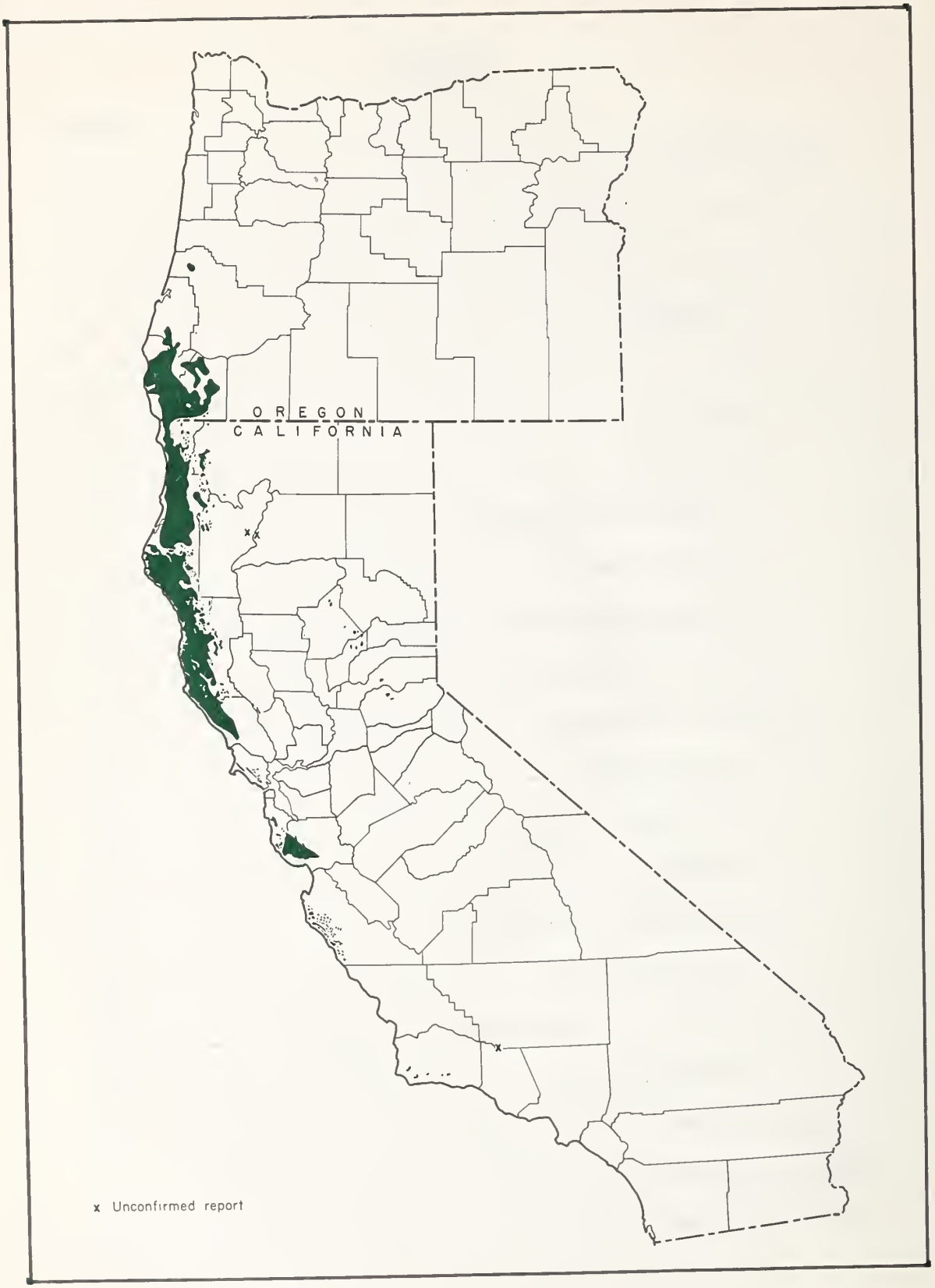

Figure 1.--The natural range of tanoak. This map was prepared by Ronald R. Tidball working under the direction of Paul J. Zinke, School of Forestry, University of California.

SILVICAL CHARACTERISTICS OF TANOAK

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Tanoak (Lithocarpus densiflorus (Hooker and Arnott) Rehder) is an evergreen hardwood which ranges from slightly north of the Umpqua River in southwestern Oregon southward through the Coast Ranges to the Santa Ynez Mountains north of Santa Barbara, California. The natural range also extends eastward from the Humboldt Bay region to the lower slopes of Mount Shasta, thence intermittently southward along the west slope of the Sierra Nevada as far as Mariposa County (fig. 1) (33). 1/ In the Sierra tanoak is most common between the Feather and American Rivers.

HABITAT CONDITIONS

CLIMATIC

Tanoak grows in a climate broadly classified as humid (45). The annual precipitation, however, is seasonal and varies throughout the natural range from 40 to 100 inches. Some precipitation falls as snow. Summer and early fall are dry and the winter rainy. The months of June through September have less than 1 inch of rain per month. In fact, precipitation during these months amounts to only 5 percent of the year's total. Most of the precipitation--about 70 percent--falls between November and February.

Average mean daily temperatures range from 36°F. to 42°F. during January and 60°F. to 74°F. in July. The last killing frosts in the spring occur between March 8 and April 30; the first killing frosts come between October 20 and November 20. The number of days free of killing frosts range between 160 and 249 (42). Over a 30-year period the maximum temperature recorded at a 600-foot elevation in the center of tanoak's maximum development was 113°F. The minimum was 9°F.

EDAPHIC

Tanoak grows well on a variety of soils developed from igneous, metamorphic, or sedimentary rocks, or sedimentary rock alluvium. It grows best on those which are deep, well-drained, and loamy, sandy, or gravelly. Tanoak also is found on serpentine sites which are

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1/ Numbers in parentheses refer to literature cited.

intermediate between the moist and dry extremes, but is limited to a shrubby form (48). It is seldom found on heavy clayey soils.

High-site soils for redwood (Sequoia sempervirens (D. Don) Endl.) or Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), such as the Hugo, Josephine, Melbourne, Empire, Sites, and Larabee series, are also well suited for the growth of tanoak. These soils have been derived from either consolidated or soft sedimentary rocks. They are light grayish brown or light reddish brown to brown in color and are moderately to strongly acid. Soil textures grade through loam, sandy loam, fine sandy loam, silt loam, to clay loam.

Besides growing well on deep soils, tanoak also thrives on stony and shallow soil phases where conifers thin out. Yet tanoak requires more moisture than many other hardwoods. It will grow well on the shallow and stony soils of north slopes, for example, but it will be supplanted by Pacific madrone (Arbutus menziesii Pursh), Oregon white oak (Quercus garryana Dougl.), or California black oak (Quercus kelloggii Newb.) on the warmer, drier south slopes.

PHYSIOGRAPHIC

Throughout the Coast Ranges from the northern limit of the natural range (latitude 43°42' N.) to the Santa Lucia Mountains (latitude 35°40' N.) tanoak grows from sea level to elevations of 4,000 or 5,000 feet. This mountainous area is geologically mature. The terrain is rough, steep, and extremely dissected both by major streams and smaller drainages. In the Santa Ynez Mountains, at the southern limit of its range (latitude 34°34' N.), tanoak grows at 2,400 to 4,700 feet. In the northern Sierra Nevada it occurs at 1,900 to 4,000 feet elevation and in the central Sierra at 3,000 to 5,000 feet (44). At its southern limit in the Sierra tanoak was discovered between 5,000 and 6,500 feet near Signal Peak (latitude 37°08' N.) in the Sierra National Forest. 2/

Tanoak is most abundant and attains its largest size in Humboldt and Mendocino Counties between elevations of 500 to 3,000 feet on northerly and easterly slopes and toward the summits of the seaward part of the Coast Range. In the southern Coast Ranges tanoak is common in the Santa Cruz and Santa Lucia Mountains, particularly on the westerly slopes. And in the central Sierra where the climate is less humid it grows in valleys, coves, ravines, along low mountain and foothill streams, and on north slopes.

2/ Wagner, Roy G. File memorandum, S-SUPERVISION, Timberland Acquisition, Redwood Region. U. S. Forest Serv., Region 5, 3 pp. Typewritten. February 17, 1937.

BIOTIC

Tanoak occurs within the life zones classified as the Canadian and the Transition (31). It is the most abundant hardwood species found in timber stands of the Coast Ranges of California and southwestern Oregon, where it is a component of four timber types. Tanoak is commonly found in the redwood and Port-Orford-cedar--Douglas-fir types, but is particularly important in the Pacific Douglas-fir and oak-madrone types (41).

The principal body of tanoak is a broad band along the inland side of the redwood belt. Here tanoak sometimes forms almost pure stands. More often it occurs as an understory tree with Douglas-fir or as a component of hardwood stands or of mixed hardwood and conifer forests. The most common hardwood associated with tanoak is Pacific madrone.

Other hardwoods occurring more or less commonly with tanoak are (10):

Acer macrophyllum Pursh	bigleaf maple
A. negundo L.	boxelder
Aesculus californica (Spach) Nutt.	California buckeye
Alnus rhombifolia Nutt.	white alder
A. rubra Bong.	red alder
Castanopsis chrysophylla (Dougl.) A.DC.	golden chinkapin
Cornus nuttallii Audubon	Pacific dogwood
Fraxinus latifolia Benth.	Oregon ash
Quercus agrifolia Nee	California live oak
Q. chrysolepis Liebm.	Canyon live oak
Q. kelloggii Newb.	California black oak
Q. garryana Dougl.	Oregon white oak
Q. sadleriana R. Br. Campst.	deer oak
Salix L., spp.	willows
Umbellularia californica (Hook. & Arn.) Nutt.	California laurel

Although we find tanoak more often with Douglas-fir and redwood than with any other conifers, it also grows with:

Abies concolor (Gord. & Glend.) Lindl.	white fir
A. grandis (Dougl.) Lindl.	grand fir
Chamaecyparis lawsoniana (A. Murr.) Parl.	Port-Orford-cedar
Picea sitchensis (Bong.) Carr.	Sitka spruce
Pinus attenuata Lemm.	knobcone pine
P. jeffreyi Grev. & Balf.	Jeffrey pine

P. lambertiana Dougl.	sugar pine
P. monticola Dougl.	western white pine
P. ponderosa Laws.	ponderosa pine
Taxus brevifolia Nutt.	Pacific yew
Thuja plicata Donn	western redcedar
Torreya californica Torr.	California torreya or nutmeg
Tsuga heterophylla (Raf.) Sarg.	western hemlock

A large variety of shrubs, forbs, grasses, sedges, and ferns also associate with tanoak. Generally these plants are not abundant on forested land, but, with tanoak sprouts, often become aggressive on burned or cutover areas. Among the shrubs are:

Amelanchier alnifolia Nutt.	western service berry
Arctostaphylos canescens Eastw.	hoary manzanita
A. columbiana Piper	hairy manzanita
A. glandulosa Eastw.	Eastwood manzanita
Baccharis pilularis DC.	coyote brush
Ceanothus cordulatus Kell.	mountain whitethorn
C. foliosus Parry	wavyleaf ceanothus
C. incanus T. & G.	white thorn
C. integerrimus H. & A.	deer brush
C. parryi Trel.	lady bloom
C. sorediatus H. & A.	jim brush
C. thyrsiflorus Eschsch.	blueblossom
C. velutinus Dougl.	snowbrush
Corylus rostrata var. californica A. DC.	California hazel
Cytisus scoparius Link	Scotch broom
Diplacus aurantiacus Jepson	brush monkey-flower
Gaultheria shallon Pursh	salal
Holodiscus discolor (Pursh) Maxim.	cream bush
Lonicera ciliosa (Pursh) Poir.	orange honeysuckle
Myrica californica Cham.	Pacific bayberry or wax myrtle
Photinia arbutifolia Lindl.	Christmas berry or toyon
Rhamnus californica Eschsch.	coffee berry
R. purshiana DC.	cascara sagrada
Rhododendron macrophyllum D. Don	Pacific rhododendron
R. occidentale Gray	western azalea
Rhus diversiloba T. & G.	poison oak
R. trilobata Nutt.	squaw bush
Ribes cruentum Greene	blood Sierra gooseberry
R. divaricatum Dougl.	straggly gooseberry
R. glutinosum Benth.	nutmeg currant
R. lobbii Gray	Lobbs or gummy gooseberry
R. menziesii Pursh	Menzies or canyon gooseberry
R. sanguineum Pursh	flowering currant

Rosa californica C. & S.	California wild rose
Rubus leucodermis Dougl.	western raspberry
R. parviflorus Nutt.	thimble-berry
R. spectabilis Pursh	salmon-berry
R. vitifolius C. & S.	California blackberry
Sambucus glauca Nutt.	blue elderberry
Vaccinium ovatum Pursh	California huckleberry
V. parvifolium Sm.	red bilberry
Vitis californica Benth.	California wild grape

Two smaller plants producing woody growth above ground are:

Chimaphila umbellata Nutt.	Prince's pine
Berberis nervosa Pursh	longleaf mahonia

Some of the forbs plentiful in the tanoak range are:

Achlys triphylla (Sm.) DC.	deerfoot vanillaleaf
Apocynum androsaemifolium L. var. pumilum Gray	mountain hemp
Adenocaulon bicolor Hook.	American adenocaulon
Cirsium arvense Scop.	Canada thistle
C. lanceolatum (L.) Scop.	bull thistle
Erechtites arguta DC.	New Zealand fireweed
E. prenanthoides DC.	Australian fireweed
Hypericum perforatum L.	Klamath weed
Lathyrus torreyi Gray	Torrey peavine
Vancouveria parviflora Greene	inside-out flower
Whipplea modesta Torr.	western whipplea

Sword fern (Polystichum munitum Presl.) and bracken (Pteris aquilina L. var. lanuginosa (Bory) Hook.) sometimes grow abundantly with tanoak. Sedges (Carex L., spp.) and grasses also are represented in some places. The most common grass species are:

Avena fatua L.	wild oat
Bromus carinatus Hook. & Arn.	California brome
B. laevipes Shear.	woodland brome
B. mollis L.	soft chess
B. vulgaris (Hook.) Shear.	narrow-flowered brome
Festuca californica Vasey	California fescue
Hierochloe occidentalis Buckl.	California sweetgrass
F. idahoensis Elmer	Idaho fescue
F. megalura Nutt.	foxtail fescue
F. occidentalis Hook.	western fescue

Animals, birds, and insects are also parts of the biotic habitat conditions under which tanoak reproduces, grows, and dies. Each plays some role in the life history of tanoak.

LIFE HISTORY

SEEDING HABITS

Flowering and fruiting

Blossoms may appear in the spring, summer, or autumn (5, 17, 44). However, most tanoaks bloom in June, July, or August (29, 46). Trees at lower elevations and near the coast bloom earlier than trees at higher elevations and further inland.

Almost all the flowers, both male and female, are borne on new shoots of the year (5, 34, 44), where they grow from the axils of the new leaves (17). Flowers also occasionally develop from buds found at the base of leaves of the previous year's growth (5, 44).

Female flowers are borne at the base of erect male catkins (7). The profusion of the yellowish blossoms which sometimes conceal the foliage suggested the tree's specific scientific name (7, 23). The calyx is pale green; the stamen filament is white; and the anther yellow.

The fruit, which is similar to oak acorns, ripens in the second autumn (22, 30, 44, 46). Acorns are usually borne singly, in twos, or in threes (17, 25, 46), but sometimes several are clustered together.

Seed production

Tanoak is a heavy seeder (9, 17, 18 20, 44). In fact, no oak on the Pacific coast produces such heavy crops of acorns (23).

In general, viable seeds are borne in abundance after the thirtieth to fortieth year (19), although 5-year old sprouts also have produced fairly heavy crops. Trees are heavily laden almost every alternate year and complete seed crop failures are rare (38). When scanty crops occur they are generally caused by frosts or a dry year. However, a long dry period at pollination time is important for setting of acorns. "Jayhawking"--peeling the bark from standing trees--has shown that girdling produces excessively large acorn crops before the trees die (20).

Mature trees produce the most acorns. One estimate places annual acorn production of a veteran tanoak 30-inches in diameter

at about 1,000 pounds (35). Since there are about 110 acorns to the pound (46), this production amounts to about 110,000 acorns. Other estimates showed that trees between 18 and 24 inches in diameter produced 3,900 to 4,600 acorns (38).

Insects destroy a significant number of acorns. One study found insect larvae infesting 51 percent of the acorns. The insects identified were: the filbert weevil (Curculio uniformis (Lec.)), the filbertworm (Melissopus latiferreanus (Wlsm.)), and a grey moth similar to Valentinia glanulella (Riley) which was tentatively identified as Holcocera sp. (38). Other insect larvae which have been found in tanoak acorns are: a cynipid (Andricus eldoradensis Beutenmüller), and two moths, one a gelechiid (family Gelechiidae) and the other a pyralid (family Pyralididae, subfamily Phycitinae) (35).

Seed dissemination

Mature tanoak acorns are dropped between September 20 and November 15. Many immature acorns have been seen on the ground as early as August 25, but these probably were knocked down by a heavy early rain.

The first acorns to fall usually are insect infested. Those falling later are sound. (Indians placed a taboo on collecting acorns for food until their medicine women held a ceremonial festival which celebrated the falling of sound acorns.) 3/

Because the acorns are large (1.0 to 2.0 inches long, (22, 46) and 0.6 to 0.7 inches in diameter) and heavy, most of them fall straight to the ground and are found under the crowns of the trees. Only a few bounce from lower branches or roll for short distances on steep slopes. In one small study, acorns were counted under trees 18 to 24 inches in diameter at rates of 78,400 to 91,500 per acre (38).

VEGETATIVE REPRODUCTION

Tanoak reproduces prolifically by vigorous sprouts which appear at practically any time under a wide variety of conditions

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3/ Radtke, Leonard B. Notes on the mast of the Hoopa (U. S. Dept. Int. Indian Serv.) 14 pp., illus. Typewritten, 1939.

(9, 47). 4/ Sprouts may start to grow after a relatively minor basal injury, after bark has been stripped from the tree for tannin extraction, or when the aerial parts of the tree are destroyed by fire or logging (17, 18, 34, 36, 44). Even healthy trees sometimes sprout.

Sprouts develop from conical woody buds which lie under the bark at the base of the tree. Most of these buds are found below the ground line. Since the number of buds varies from few to thousands the number of sprouts also varies. As many as 1,400 have been counted on one large stump. The only mechanical damage which prevents sprouting occurs when bark is stripped below the ground level and the buds are exposed (20, 23).

Sprouts grow rapidly in good light. Measurements show they may grow as tall as 5.6 feet the first year and 13.6 feet in the fifth year. The size of the parent tree determines the height and diameter growth of sprout clumps, and the number of sprouts in a clump. Larger parent trees produce greater sprout development. The living sprouts are reduced drastically in numbers early in their life and growth is concentrated on the dominant stems (table 1) (36, 37). In the first 15 or 20 years sprouts will average about 2 feet in height a year. Often, a circle of 4 to 8 slender 30-year old poles grows around the stump of a parent tree (20, 21). These poles will average 12 to 15 inches in diameter (14).

Although not as aggressive as sprouts of some other associated hardwoods, such as bigleaf maple, madrone, and Oregon white oak (36), tanoak sprouts are much more important as competitors because tanoak is more abundant, especially in conifer stands. It often quickly dominates the vegetational cover after logging or fire. Although this ability helps reduce soil erosion, tanoak sprouts often provide severe competition to conifer reproduction and may suppress it. And the thick, stiff, flat, leathery leaves which decay slowly often smother young conifer seedlings and transplants or cover the ground so thoroughly that conifer seeds cannot germinate (10, 30, 36, 37).

Propagation of tanoak by grafting or cuttings has not been reported.

4/ Wagner, Roy G., op. cit.

Table 1.--Tanoak sprout development

Time after burning or logging	Sprout clumps measured	Height of tallest sprout in clump: Ave.	Height of tallest sprout in clump: Range	Crown diameter of sprout clumps: Ave.	Crown diameter of sprout clumps: Range	Sprouts per clump: Ave.	Sprouts per clump: Range
	Number	Feet		Feet		--Number--	
Logged:							
First year	120	2.4	0.7 -5.6	2.6	0.6 -7.4	16	1-162
Burned:							
Second year	50	5.2	2.2 -8.3	6.2	2.9-11.5	27	7 -79
Third year	50	6.8	2.2-10.3	7.0	3.4-12.1	12	4 -25
Fourth year	50	7.9	2.3-11.3	8.4	3.4-14.3	10	4 -25
Fifth year	50	9.3	2.7-13.6	9.9	4.8-15.2	10	4 -25
Sixth year	49	10.3	3.5-14.7	10.3	5.0-15.6	9	1 -25

SEEDLING DEVELOPMENT

Establishment

Under proper conditions tanoak reproduces well by seed. Acorns germinate readily in sunny, open spots (21) where the seedbed is a loose, mineral soil. However, the dense shade of virgin forests, and the thick litter found under tanoaks, madrones, or other hardwoods, seem to hinder germination. Seedlings are rare in these places (21). Tanoak germination is hypogeous.

A limited number of tests show germination rates vary from 19 to 80 percent (20, 46).

Seedlings may appear in the fall if the weather is mild. Seed collectors have found that acorns must be planted immediately in light soil. Seedlings appear 3 weeks after planting. To retard germination until spring, acorns must be stratified at a temperature just above freezing (46).

Natural tanoak seedlings have been counted under parent trees left after the Douglas-fir overstory had been cut. Although one year's acorn crop produced 160 to 380 seedlings per acre under trees 20 to 26 inches in diameter, the efficiency of the sound acorns in producing seedlings was only 0.64 percent. This means only 1 seedling grew from 156 sound acorns (38).

Biotic factors contribute to the low seed crop efficiency. Although the acorns have hard seedcoats 5/, many animals devour them with gusto. Some of these animals are (38) 6/:

Balanosphyra formicivora bairdi (Ridgway)	California woodpecker
Columba fasciata fasciata Say	band-tailed pigeon
Cyanocitta stelleri frontalis (Ridgway)	blue-fronted jay
Ixoreus naevius naevius (Gmelin)	Pacific varied thrush
Eutamias townsendii Bachman	Townsend chipmunk
Neotoma fuscipes fuscipes Baird	dusky-footed wood rat
Otospermophilus grammurus douglasii (Richardson)	Douglas ground squirrel
Sciurus douglasii mollipilosus (Audubon & Bachman)	redwood chickaree
Sciurus griseus griseus Ord.	California gray squirrel
Euarctos americanus americanus (Pallas)	American black bear
Odocoileus hemionus columbianus (Richardson)	Columbian black-tailed deer

Hogs and cattle also prevent seedling reproduction by devouring the acorns and browsing the tender foliage of seedlings (19).

Early growth

First-year growth of tanoak seedlings is vigorous. Heights measured from cotyledons to growing tip in one study varied from 1.9 to 8.3 inches and averaged 5.2 inches. These seedlings were measured on July 22. Therefore, total first-year growth might have been more. The heights in July, however, were greater than first-year height growth of conifers on the same site (38). After the first year the seedling growth rate is moderate (19).

5/ The generic name, Lithocarpus, from the Greek "Lithos" meaning rock, and "karpos" meaning fruit, alludes to the hard acorn (29).

6/ Knauss, A. C. File memorandum. RP-NW-TIMBER CONVERSION, Utilization, Tan Oak (U. S. Forest Serv., Pacific Northwest Region) 4 pp., illus. Typewritten. April 15, 1947.

New tanoak seedlings quickly develop a husky tap-root. By the end of July many seedlings have roots penetrating more than 24 inches deep. Tanoaks eventually grow a deep tap-root system (34). Seedlings, however, have difficulty to survive on dry, unprotected slopes.

Although best early growth is found where seedlings get partial shade, tanoak is intolerant to heavy shade during its early growth. It becomes more shade-enduring with age (35).

SEASONAL GROWTH

Records on the seasonal growth of tanoak are scanty. Some observations have been made in the vicinity of Salyer, California. Here, in the Trinity River valley and on the low mountain slopes up to 2,000 feet elevation, tanoak vegetative buds open in mid April. From 2,000 to 3,500 feet buds burst in mid May; from 3,500 to 4,400 feet in late May. At its elevational limit, which is about 4,500 feet buds open in early June. The new leaves of a season persist for 3 to 4 years (5, 44).

The growing season lasts 4 to 5 months in the mountains and somewhat longer at lower elevations and nearer the coast.

SAPLING STAGE TO MATURITY

Growth and yield

The form of tanoak varies greatly. The four general forms of growth are: the spire shaped, similar to conifers; the round headed; the shrubby or deep shade form; and the stunted chaparral form. In close stands, particularly the dense coniferous forests, tanoaks develop one central axis, the crowns are narrow, the branches upright and the trunks long and clear for 30 to 80 feet. In this form tanoak is one of the most stately broadleaved trees in the west. In open stands, however, especially in association with Pacific madrone and California black oak, tanoaks are free branching, the crowns are broad, the limbs horizontal and large, and the trunks short and thick. The main trunk divides into several large branches and forms a rounded crown (17, 20, 23, 44).

Tanoak usually is classed as medium sized (46). Mature trees generally are 50 to 90 feet tall but frequently grow 150 feet high (17, 22, 35, 39, 44). The tallest tree reported was 208 feet high and 4.5 feet in diameter. It was found on the North Fork of the Little Sur River, Monterey County, California. 7/

7/ Larsen, L. T. File memorandum. U. S. Forest Serv. Region 5. 1 pp. June 26, 1914.

The diameters of mature trees usually vary from 1 to 4 feet (17, 20, 35, 39, 44). 8/ The largest diameter breast high of record is 7 feet 7.9 inches, measured on a tanoak near Cazadero, Sonoma County, California. The height of this tree was 80 feet and its crown had a spread of 84 feet (2). Tanoaks growing largest in diameter are generally found in open stands where height growth is less. The following tabulation illustrates the diameter-height relationship (20). 9/

Diameter, inches:	Height, feet:	Age, years:
4 - 9	30 - 50	20 - 40
10 -12	40 - 80	40 -100
13 -18	80 -100	70 -125
19 -24	90 -120	100 -159
25 -36	115 -140	125 -180
37 -46	100 -120	150 -210
47 -60	100 -120	170 -250

The growth of tanoak has been called slow (39, 47), moderate (34), and fairly rapid (18). Exact knowledge about growth rate is limited, for only a few trees have been measured. Seven trees near Sherwood, Mendocino County, California, which varied from 14 to 27 inches in diameter 2 feet above the ground, had from 10 to 20 rings per inch (23). At another place, trees 48 years old averaged 10 inches in diameter and 35 feet tall. Trees 14 to 18 inches in diameter were from 80 to 128 years old; 20 to 60 inch trees, from 150 to 250 years old (44).

The age at which trees mature differs for various sites. One report gives the age of mature trees as 80 to 190 years (20); another states maturity is reached in 200-300 years (34). The average age of tanoaks in virgin stands seems about 180 years (14).

8/ Knauss, A. C., op. cit.

9/ Bauer, Patricia McCollum. History of lumbering and tanning in Sonoma County, California since 1812. Thesis (M.A.), Univ. Calif., 189 pp., illus. Typewritten, 1951.

The present sawtimber volume of tanoak has been estimated as 2,036 million board-feet in California and 1,700 million board-feet in Oregon (16, 40). The volume of tanoak on commercial forest land in California is divided into diameter-class groups as follows (15):

Diameter class group, inches:	Volume, million board-feet:
11.0-20.9	855
21.0-30.9	765
31.0-40.9	329
41.0 +	87
	2,036

Reaction to competition

Tanoak is generally rated as tolerant (3, 4, 34). It is aggressive and extremely well-fitted by its reproductive habits, vigor, and remarkable shade endurance to compete for possession of the ground (20). Although tanoak can endure considerable shade throughout life, it grows best with top light (17, 44). In conifer stands where it has an equal opportunity to grow, it is able to compete with redwood and Douglas-fir (20). In dense stands natural pruning produces long clear boles (17).

Under stands of dense redwood or Douglas-fir where tanoak obtained a late start, low tanoak shrubs or small trees may be abundant. When the coniferous overstory is removed, the tanoak quickly dominates the logged areas (20, 23). Suppressed trees often develop with remarkable speed after being released from dense shade (19).

Tanoak is a climax species where it grows in the broad-sclerophyll forest formation which is dominated mainly by sclerophyllous evergreen trees but includes a number of deciduous species. It is successional, however, where its range overlaps those of conifers, and postclimax in its overlap with the climax chaparral (10).

Principal enemies

Fire is the principal enemy of individual tanoak trees (9, 17, 23). Ground fires, as well as crown fires, are sometimes fatal. More often, however, fires will leave long vertical wounds reaching from 4 to 10 feet up the trunks (23). Although the bark of mature trees is at least 1 to 3 inches thick, and occasionally 4 or 5 inches (23), some trees are burned badly.

Fire injuries to small trees often heal over, but fungi usually enter the wounds on older trees. The exposed wood on these larger trees rots and the wounds do not heal (23). Sometimes one-third to one-half the diameter of the tree is eaten away as a result of repeated fires and decay. If decayed wood catches fire it burns readily and the original wound is enlarged.

Until injured by fire, tanoak is relatively free from insects and fungus diseases, and is windfirm (9, 17, 47). Even slight injury to the trunk, however, allows fungi to enter. Wind and heavy snows eventually fell many trees originally injured by fire and subsequently weakened by decay.

Fire and fungi cause tanoak to be fairly defective. 10/ A large part of this defect occurs in cull trees--sawlog-size trees where more than 60 percent of the board-foot volume is cull. One study (27) based upon 90 trees showed the percentage of sawlog cull (from stump to top diameter of 10 inches) to be:

	All trees	Cull trees	Trees not cull
		-Percent-	
Cubic feet basis	13	39	8
Board-feet (Scribner) basis	33	80	26

Fungi found on living trees are the beefsteak fungus (Fistulina hepatica (Huds.) Fr.)--which causes a brown cubical rot, the weeping conk (Polyporus dryadeus Fr.)--a white root rot, and a necrophyte (Shizophyllum commune Fr.)--which causes a sap rot on injured areas of standing trees. 11/

Several insects have been found feeding on tanoak but generally are minor in importance. Two of these are armored scales identified as the greedy scale (Hemiberlesia rapax (Comstock)) and the oak scale (Quernaspis quercus (Comstock)) (28). The greedy scale chiefly infests the bark but also occurs on the leaves. The oak scale feeds on the undersides of leaves. Two other insects which resemble the soft unarmored scales also feed on the undersides of leaves. They are the glacial white fly (Trialeurodes glacialis Bemis) and the Stanford white fly (Tetraleurodes stanfordi Bemis). Ehrhorn's oak scale(Mycetococcus ehrhorni (Ckll.)) is found on stems and the white sage mealybug (Pseudococcus crawi Coquillett) on stems and leaves (13).

10/ Knauss, A. C., op. cit.

11/ From the Host Index File, Division of Forest Disease Research, California Forest and Range Experiment Station.

In 1957 the California oakworm (Phryganidia californica Pack.) completely destroyed the current year's foliage of tanoaks growing on Hennessey Ridge, near Salyer, Trinity County. This damage was localized and was not observed at other places nearby.

Other insects work under the bark. Adults of a twig girdler, Agrilus angelicus Horn, feed on foliage, but its larvae mine spiral galleries which girdle twigs, small limbs and trunks, or sprouts. The California oak twig girdler (Styloxus californicus (Fall)), a long-horned beetle or roundheaded borer, also girdles tanoak sprouts (17, 24).

Tanoak is avoided by livestock unless better feed is unavailable (11). Columbia black-tailed deer (Odocoileus hemionus columbianus (Richardson)) rarely browse it (47). The current year's growth of tanoak leaves and twigs is protected by a covering of fasicled hairs, which are unpleasant to inhale.

SPECIAL FEATURES

Tanoak and the other trees in the genus Lithocarpus Blume are considered links between the chestnut, Castanea Mill., and the oak, Quercus L. (12, 29). The chestnut characteristics of tanoak are the erect elongated catkins, parallel lateral veins of the leaves, pistillate flowers at the base of the staminate catkins, and a bur-covered acorn cup. Some of the oak characteristics are the acorn cup instead of a closed bur, the single pisillate flower in an involucre, and the bitter tasting true acorn (29). One successful attempt to graft European chestnut (Castanea sativa Mill.) scions to tanoak stumps has been reported from southern Mendocino County. 12/

Tannin from tanoak bark also has properties intermediate between chestnut tannin and the usual oak tannin of commerce (26). However, the extract from tanoak bark furnishes the best tannage known for the production of heavy leathers (20, 21). For example, it gives excellent plumping when used to tan sole or saddle leather (26). The superiority of tanoak bark extract is attributed to the presence of certain other acids, such as gallic and acetic, with the tannic acid (20). Tanoak tannin has also been used medicinally (43).

12/ Source of information was Mr. "Buck" Zeni, Zeni Ranch, Yorkville-Anchor Bay Road, Mendocino County, California, through Paul J. Zinke, School of Forestry, University of California.

In relation to tannin production, tanoak is the most important Pacific Coast hardwood (18)--first, because the bark is rich in tannin (19, 46) and, second, because the trees are abundant. The area occupied by tanoaks suitable for tannin production has been estimated at 3 million acres with an average count of 20 trees per acre (6).

The tannin content of tanoak bark varies between 8 and 29 percent (14, 18, 26). Trees must be at least 75 years old before the bark is valuable for its tannin. 13/ In individual trees the tannin content is highest in the bark near the base of the trunk (1) and decreases with height above the ground. 14/

Trees growing on better sites produce less extract from a given volume of bark than those on poorer sites where growth is slower. 15/ The best bark comes from trees growing on ridges, open grown trees, or trees growing in scattered clumps. When grown in dense stands or mixed with other species tanoak will yield less valuable bark. 16/

Tanoak sapwood is extremely thick, the sapwood percentage being as high as 66 percent even on large trees (16). This thick sapwood helps the tree live after the bark has been stripped. Consequently, standing trees sometimes live several years after being peeled, but they never produce a second crop of bark which has commercial value. 17/ The root systems of peeled trees which survive probably are fed by sprouts or by other trees through natural root grafts.

The Indians in California's North Coast Range obtained one of their principal foods from the tanoak. In fact, the main fare of many Indian communities was salmon and tanoak acorns. The large acorns were ground, leached, and then prepared as a soup, cooked mush, or kind of bread. After being leached, the acorns are said to have an agreeable acid taste. They also contain a comparatively

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13/ Wagner, Roy G., op. cit.

14/ Smith, H. H., Utilization of tanbark oak. U. S. Forest Serv. Calif. Forest and Range Expt. Sta. 1 p. Typewritten. 1950.

15/ Wagner, Roy G., op. cit.

16/ Smith, H. H., op. cit.

17/ Jepson, Willis Linn. The tanbark oak and its relation to the California tanning industry. (File, U. S. Forest Serv. Calif. Forest and Range Expt. Sta.) 40 pp., Typewritten. 1910.

large amount of oil. On this account tanoak acorns were preferred by the Indians over all other kinds. Ground tanoak acorns have also been fed to chickens (8, 20, 35).

RACES AND HYBRIDS

A shrubby variety of tanoak (L. densiflora var. echinoides (R. Br.) Abrams) grows near Mount Shasta, on the west slope of the northern Sierra Nevada, in the Salmon and Klamath Mountains, and northward through the Siskiyou Mountains into southern Oregon (29). 18/ 19/ This dwarf or mountain variety is part of the chaparral cover found on mountain tops and ridges. It assumes many of the characteristics of the other chaparral shrubs, such as low stature, ranging from 1 to 10 feet high, rigid branches, and small, thin leaves (23).

There are no known hybrids of tanoak. Although Lithocarpus comprises about 100 species, all but tanoak are native to southeastern Asia (18).

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